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The Effects of Parallelism and Prosody in the Processing of Gapping Structures

Katy Carlson
University of Massachusetts, Amherst

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0. Abstract

How do perceivers assign an interpretation to an ambiguous sentence like *Bill took chips to the party and Susan to the game,* which may be assigned a gapped (Susan took chips) or a non-gapped structure (Bill took Susan)? The results of two experiments designed to answer this question suggest that the interpretation of such sentences is influenced by parallels between arguments in their syntactic features and in their prosody. But the most important determinant of an interpretation is structural economy. The gapped analysis involves building more structure than the non-gapped interpretation, so it is dispreferred.

1. Introduction

Gapping is an optional syntactic process that seems to delete identical material from the second of two conjoined sentences, as in the following examples:

(1) a. Some ate beans and others rice.
b. Sam gave a note to Sarah and John to Sue.

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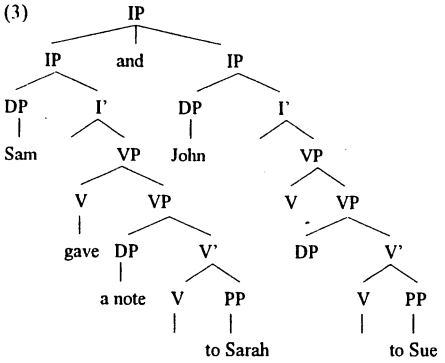
The deleted material always includes the verb, and may also include further constituents such as the object (Johnson, 1997; Kuno, 1976; Sag, 1980). The second conjunct is left with only new material, usually the subject and a postverbal element. A gapping sentence with the form of (1b) is potentially ambiguous, in that the DP following and could be the subject or the object of the verb. The sentence could contain two conjoined sentences, one of which is incomplete (2a), or contain conjoined sets of arguments below the verb (2b):

(2) a. [Sam gave a note to Sarah] and [John to Sue]
b. Sam gave [a note to Sarah] and [John to Sue]

This particular example favors the reading in (2a), since John is a better subject than object, and is more parallel to the subject of the first clause, Sam, than the object, a note. Notice that in both cases, the PP has the same syntactic relation to the verb. The main ambiguity is what structural position is given to John, the DP after the conjunction (which I will call the ambiguous DP). The resolution of this ambiguity will be the focus of the present work, since few studies of the processing of ambiguous ellipsis sentences exist.

The conjoined sentences in this study will all contain a subject, verb, object, and PP, as in (1b) and (2). One simplified syntactic structure for this sentence, on the gapping analysis, is shown in (3):[2]

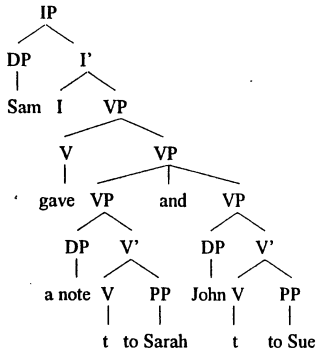
(3)



I assume that a complete syntactic structure such as (3) is built for an ellipsis sentence. This structure is then interpreted through copying of information from the first conjunct (see Dalrymple, Shieber, & Pereira, 1991, for one explicit way of interpreting an ellipsis structure). On the other analysis, this sentence would have a simpler structure in which only the arguments below the verb are conjoined, as shown in (4):

[2] See Johnson (1997) for a review of the syntax of gapping and a discussion distinguishing it from other types of ellipsis, as well as a new proposal about the mechanism and structures involved in gapping. Larson (1988) presented the original proposal that constituents like those conjoined in (4) could exist.

(4)



Note that the structure in (4) is smaller than that in (3), in that it contains fewer nodes. (The details of these structures are not important to this research; it is only necessary for the gapping analysis to be full clausal conjunction, while the non-gapping analysis involves conjunction of some lower phrasal category.)

There are several plausible ways that one could imagine processing an ambiguous gapping sentence. In ellipsis structures like gapping, the material after and will be a set of unconnected constituents, with less lexical and syntactic information available for structuring the sentence than usual. Any other sources of information, such as analogies to the complete first conjunct, ought to be useful in determining the roles of ambiguous arguments. So, one might use the parallels between conjuncts to line up the arguments in the incomplete second conjunct.

Several studies have shown that in conjunctions, even without ellipsis, parallelism of many types is helpful to the processor, in that the second conjunct is easier to process if it is parallel to the first in some way (e.g., Black, Coltheart, & Byng, 1985; Frazier, Clifton, & Munn, 1997; Frazier, Taft, Roeper, Clifton, & Ehrlich, 1984). In Frazier et al. (1984), ungapped conjoined sentences were constructed using matching and non-matching structures, such as object DPs vs. sentential complements (e.g., Jim believed all Tom's stories (were literally true) and Sue believed Jim's stories (were fictitious)). Other conditions alternated verb passivity, object animacy, subject thematic roles, and heavy NP position. In most conditions, parallelism affected reading times for the second conjunct, showing that the second conjunct was easier to process if it was similar to the first. Frazier et al. (1997) found that conjoined phrases of like syntactic category and phrases of approximately the same size were processed faster than non-parallel phrases. Similar preferences were observed in a sentence-completion study by Altmann, Henstra, and Garnham (1993), and following work by Henstra showed that subjects preferred the definiteness of conjoined NPs to match (as cited in Frazier et al., 1997). Turning to gapping, Grosu (1985) showed that syntactically non-parallel constituents could be acceptable in gapping sentences, under certain focus conditions. But Black et al. (1985) showed that processing was impeded when the subjects of gapping clauses differed in number, even when that did not affect the form of the gapped verb (e.g.,

Your **aunts** saw ghosts and Mary apparitions is less acceptable than Your **aunt** saw ghosts and Mary apparitions).

This work suggests that parallelism can be an important factor in the processing of conjoined elements. I will test the hypothesis that parallelism might have a very central role in creating an initial structure, as laid out in the following hypothesis:

(5) Strong Parallelism Hypothesis
a. parse each minimal constituent after a conjunction as a DP or PP, etc.
b. compare the post-conjunct constituents to first conjunct constituents, and line them up in the same syntactic positions as the constituents they are most parallel to
c. build syntactic structure placing parallel constituents in parallel syntactic positions

On this hypothesis, the parser processes the words in the second conjunct, forming minimal phrasal constituents, and then immediately looks back to the first conjunct. It evaluates whether the second conjunct constituents are like particular constituents in the first conjunct, and lines them up accordingly into a syntactic tree. There are numerous ways to vary the parallelism of constituents such as arguments: these include the manipulation of syntactic factors like definiteness, number, and form (proper names vs. other noun phrase types) as well as more semantic factors like animacy, gender, and coherence within a field (e.g., nurse and doctor are both terms from medicine, and thus more parallel than nurse and engineer). If the DP following and is very much like the subject of the first conjunct, and not like the object of the first conjunct, a gapping analysis would be favored over a lower conjunction analysis, since this ambiguous DP would be placed in the subject position of the second conjunct.

When we turn to auditory processing, prosody is another possible source of information. Prosodic factors have been used to disambiguate structures in numerous other studies (e.g., Lehiste, 1973; Price, Ostendorf, Shattuck-Huffnagel, & Fong, 1991), and have been shown to be important in at least one other ellipsis construction, Right-Node Raising (Selkirk, 1997b). Parallelism of prosodic elements such as prosodic boundaries, pitch accents, and pitch range could be used here to line up arguments in a gapped conjunct. Before looking at prosodic factors in the processing of gapping sentences, though, we should find out how their syntactic structures are built independent of prosody, and how factors such as structural parallelism are used. That way we can look at prosodic factors in sentences for which the baseline structural bias has already been determined. Therefore, the first study presented will be a reading study.

It may be that processing a gapping sentence is not as special an endeavor as the previous hypothesis suggests; perhaps simple structural preferences determine the favored structure. This is expressed in the following hypothesis:

(6) Minimal Structure Hypothesis
a. build up constituents using no more nodes than necessary
b. evaluate structures using semantics, parallelism, pragmatics, and prosody
c. choose the most economic structure consistent with this information

This hypothesis postulates that the language processor builds up the smallest syntactic structures that are consistent with the input. In a gapping sentence, the smallest structure will be a lower conjunction structure, as in (4). But since further information can be considered, factors like parallelism between arguments and the pragmatic likelihood of this smallest structure can help favor the gapping structure in (3) instead. Under this hypothesis, gapping sentences and conjunctions are treated much like any other sentences of the language. The strongest version of this hypothesis would claim that structural economy is the main factor determining an analysis, so that the less economical gapping structure should only be favored when several types of information suggest it. The Minimal Structure Hypothesis is clearly based on and consistent with the Minimal Attachment principle in the Garden Path model (e.g., Frazier, 1978; Frazier & Rayner, 1982; Frazier, 1987).

The frequency and acceptability of some types of gapping sentences have been questioned since early work on the constructions (as reviewed in Sag (1980)). Hankamer (1971) proposed that gapping sentences of just the structure under discussion here were impossible, because they were ambiguous with a simpler structure. Kuno (1976) and others noted that Hankamer's examples were constructed with all arguments parallel to each other, with little information to support a gapping analysis. Thus Kuno claimed that these sentences were possible as long as information to favor a gapping analysis was present. I have adopted this view, since I also find these sentences acceptable. Furthermore, some subjects in my experiments gave up to 80% gapping analyses of these sentences, suggesting that gapping structures are acceptable to at least part of the subject population as well. It is true, though, that the predictions of a frequency-based account of the processing of gapping sentences might be basically indistinguishable from the predictions of a structure-based hypothesis, since the gapping analysis of these sentences is likely to be less frequent than the argument conjunction analysis.[3] I suggest that the ambiguity of these gapping structures with the simpler conjunction analysis could help explain their relative infrequency; thus the Minimal Structure Hypothesis could be viewed as a theoretical rationale behind a frequency argument, which is otherwise simply an empirical observation.

The hypotheses presented in (5) and (6) obviously differ in their predictions. The Parallelism Hypothesis proposes that parallels between arguments in the gapped conjunct and the first conjunct are used to structure the input. If the ambiguous DP is more like the subject of the first conjunct, then a gapping analysis should be reached; if the ambiguous DP is more like the object of the first conjunct, then a lower conjunction analysis should be picked. The Minimal Structure Hypothesis proposes that general structural economy helps determine the structure that is built and other factors are used to evaluate computed structures. If structural economy is the most important factor, then the lower conjunction analysis should always be favored, and the gapping structure should only be picked if several other factors suggest it (such as semantic anomalies based on the verb or parallels between arguments).

[3]The frequency of structures does not always correlate with their syntactic complexity (Gibson, Schutze, & Salomon, 1996), so in principle the frequency of gapping structures could be higher than that of the less complex conjunction structures. The greater syntactic complexity of gapping structures, though, is known, and correlates with the results of the studies presented here.

2. EXPERIMENT I

This experiment was designed to test the Minimal Structure and Parallelism Hypotheses about the processing of gapping sentences, and thus evaluate the relative importance of structure and parallelism in processing ellipsis sentences.

Method

Subjects. The students in a Linguistics 101 course at the University of Massachusetts, Amherst participated in this experiment as part of one of their weekly section meetings. The data of non-native English speakers were then excluded, as well as that of subjects who were unable to finish the questionnaire during the time allotted, leaving a total of 68 subjects. The subjects had not been exposed to analyses of any sentences as complicated as those that were part of the study, so there is little chance that they knew too much about the sentences due to this class.

Stimuli. In designing this experiment, I found that verbs strongly affected the parallelism of arguments in a sentence, due to their selection restrictions. The three verb types used to form different conditions will be explained with reference to the experimental sentences in Table 1:

Table 1: Sentences for Experiment I

Condition	Example sentences
Bake A	Alice bakes cakes for tourists and Caroline for her family
Bake B	Alice bakes cakes for tourists and brownies for her family
Take A	Josh visited the office during the vacation and Sarah during the week
Take B	Josh visited Marjorie during the vacation and Sarah during the week
Introduce	Dan amazed the judges with his talent and James with his musicality

Some verbs, like bake, usually have human subjects, but non-human objects. So in the Bake A example, Caroline is a better subject of bake than it is an object, since one doesn't usually bake people, and it is parallel only to the subject of the first clause in animacy. Verbs like take or visit can have human or non-human objects, so the ambiguous DP (Sarah) could be parallel in animacy to both the object and the subject, as in the Take B examples, or the subject alone, as in the Take A examples. And verbs like introduce or amaze only take human arguments, so the ambiguous DP (James) is at least parallel in animacy to both arguments in the first conjunct of the Introduce sentence. (A listing of the experimental sentences in this study can be found in the Appendix.)

The materials in this experiment were constructed to allow several main comparisons. First, sentences with parallelism between the first clause subject and the ambiguous DP (and non-parallelism between the object and the ambiguous DP) were constructed within each verb type: the Bake A, Take A, and Introduce sentences. (The ambiguous DP after and is italicized in each sentence above, along with whichever argument it is consistently parallel to.) These

sentences differ in how much parallelism is allowed by the verb, since Bake verbs must take non-human or inanimate objects while Introduce verbs must take all human arguments. Thus the ambiguous DP in a Bake A or Take A sentence is parallel in animacy and number, gender, or definiteness to the subject, and not the object; the ambiguous DP in an Introduce sentence is parallel in animacy to both prior arguments, but parallel in number, gender, or definiteness only to the subject. The sentences also differ in which analysis the pragmatics favors; for example, the Bake A sentences are implausible on the non-gapping analysis, because that puts the human ambiguous DP in an object position with a verb that prefers inanimate objects, while the Take A and Introduce sentences are fairly natural on both analyses. Thus the comparison between the Bake A, Take A, and Introduce sentences is expected to show that the parallelism and pragmatic factors bias the results toward gapping most in the Bake A sentences, and least in the Introduce sentences.

Second, the other two sentence types were designed to check the sentence biases in conditions of neutral or opposite parallelism. Specifically, the Bake B sentences have inanimate ambiguous DPs which are parallel only to the object, not the subject, of the first clause; comparison of these sentences to the Bake A sentences will show whether the biasing factors of parallelism and plausibility are equally able to favor the gapping and non-gapping analyses. The Take B sentences have the object of the first clause as animate and slightly parallel in form to either the first subject or the ambiguous DP; comparison of these sentences to the Take A sentences will show whether the stronger parallelism in the Take A sentences is able to favor the gapping analysis.

Procedure. This experiment was a written questionnaire study. The sentences were divided into two lists so that subjects would not have to answer too many questions. Within these lists, there were two conditions, based on which Bake and Take sentences were in the A and B parallelism conditions, for a total of four questionnaire types. Thus each subject saw 7 Bake sentences (3 or 4 Bake A versions and 4 or 3 Bake B versions), 6 Take sentences (3 Take A's and 3 Take B's), 5 Introduces, and 12 filler sentences of varying ambiguity, for a total of 30 sentences. The order of the sentences on each questionnaire was randomized and then amended so that consecutive sentences were never of the exact same type. The four different questionnaire versions were handed out in mixed order. Each type was completed by 14-19 subjects.

The experimenter read instructions to the subjects. Each sentence on the questionnaire was followed by three questions. The first question asked them to select the best paraphrase of the sentence. They were given two choices plus a space to write in their own paraphrases if they didn't like either of the choices provided. For the sentence Alice bakes cakes for tourists and Caroline for her family, the two paraphrases were a) Alice bakes cakes, and she bakes Caroline, too (the non-gapping analysis) and b) Alice and Caroline bake for people (the gapping analysis). The order of the choices was varied, so that the gapping paraphrase was the first choice only half of the time. The second question asked subjects to rate on a scale of 1-5 how hard it was to understand the sentence, with 5 as hard. The third question asked subjects what other meaning the sentence might have, and gave them space to write in an answer. They were also encouraged to write in 'a' or 'b', if the paraphrase they hadn't picked in the first question was another possible meaning. This third question was interpreted as a rating of the ambiguity of the sentence.

Stimulus Pre-testing. The verb groupings and the plausibility of the sentences in this study were tested with a separate group of subjects. To ensure that the verb types in this study actually differed in what type of object they selected for, 6 subjects were instructed to fill in the object blanks in unconjoined sentence frames using all of these verbs (e.g., Alice bakes ___ for ___).[4] Bake verbs took inanimate objects 94.1% of the time, Take verbs took non-human or inanimate objects 75% of the time, and Introduce verbs took inanimate objects only 8.3% of the time (differences are significant: Bake vs. Introduce, $F = 86.8$, $p < 0.001$; Bake vs. Take, $F = 4.8$, $p = 0.04$; Take vs. Introduce, $F = 49.1$, $p < 0.001$). This confirms that the verbs have distinct subcategorizations, with Take verbs as the most variable.

The plausibility of sentences in this study was confirmed by having 12 subjects rate unambiguous clauses corresponding to the complete conjuncts built on the different analyses. Thus for each Bake sentence frame, five clauses were rated for plausibility, as in the following list:

(7) Original: Alice bakes cakes for tourists and (A-Caroline/B-brownies) for her family.
Tests: a. Alice bakes cakes for tourists (First clause)
b. Alice bakes Caroline for her family (Non-gap A)
c. Alice bakes brownies for her family. (Non-gap B)
d. Caroline bakes cakes for her family. (Gap A)
e. The brownies bake cakes for the family. (Gap B)

All subjects rated the common first clause, (a), as well as one of the plausible clauses, (c) or (d), and one of the implausible clauses, (b) or (e). Similar sets of sentences were constructed for the Take and Introduce sentence frames (except that the Introduce sentences only came in an A version, so only three clauses could be tested); implausible filler sentences were added to form two lists of 110 sentences. The average plausibility ratings are shown in the table below, with 1 being plausible and 5 being implausible (SDs in parentheses):

Table 2: Experiment I Materials Plausibility Ratings

	Bake verbs	Take verbs	Introduce verbs
First clause	1.2 (0.26)	1.1 (0.24)	1.1 (0.21)
Non-gap A	4.3 (0.50)	1.2 (0.21)	1.2 (0.21)
Non-gap B	1.0 (0.06)	1.3 (0.33)	na
Gap A	1.2 (0.16)	1.2 (0.26)	1.2 (0.41)
Gap B	4.8 (0.30)	1.3 (0.40)	na

[4]The use of a following prepositional phrase, as in the experimental sentences, caused subjects to produce DPs in the blank after the verb on all but one trial.

From this table, it is clear that most of the sentences were quite plausible, and that there was little variability in the plausibility ratings.[5] The only significantly implausible experimental conditions were the Bake conditions containing either an animate object (Non-gap A) or an inanimate subject (Gap B), against the verb's selection preferences (Non-gap A vs. Non-gap B, $F_1 = 853$, $p < 0.001$; Gap B vs. Gap A, $F_1 = 1573$, $p < 0.001$). This confirms that response differences between these sentence types will be based on factors other than plausibility (that is, subjects will not choose more gapping analyses for a sentence type simply because of a difference in the plausibility of the analyses, except in the Bake sentences, where plausibility was manipulated on purpose).

Results

The total percentages of gapping and non-gapping responses for Experiment I by subjects, as well as the ambiguity and difficulty ratings, are shown in Table 3.

Table 3: Results of Experiment I

Condition	% Gapped Answer	% Other Analysis Possible	Gap Difficulty Rating	% Non-Gapped Answer	% Other Analysis Possible	Nongap Difficulty Rating
Bake A	**81.1**	22.7	2.43	18.9	18.5	2.83
Bake B	3.7	(5.0)*	(2.7)*	**96.3**	2.1	1.91
Take A	40.2	37.8	3.07	**59.8**	13.0	2.47
Take B	3.9	(16.7)*	(3.42)*	**96.1**	8.7	2.11
Introduce	20.9	(12.6)*	2.45	**79.1**	15.2	2.45

*Note: these averages are based on data from only a few items, due to low gapping response rates, and should thus be considered speculative

The Bake A sentences (with gapping-biased parallelism and plausibility) were given the gapping analysis 81.1% of the time, and 22.7% of these responses were rated as ambiguous, in that the other interpretation was possible. The ambiguity percentage for the non-gapping analysis was similarly high (18.5%), which makes sense considering the implausibility of this analysis. The Bake B sentences received the gapping analysis only 3.7% of the time, and ambiguity percentages were low for both analyses. Thus the gapping analysis was picked most often for the Bake A sentences, but they were rated as quite ambiguous on either analysis, while the Bake B sentences were unambiguously non-gapping. The difference in ambiguity ratings between Bake A and Bake B sentences was significant (Bake A gapping vs. Bake B non-gapping: $t(13) = 5$, $p < 0.001$). The Bake A sentences were also rated as more difficult

[5]There was one sentence of the Take type which appeared to be less plausible than the rest (2.33 plausibility rating vs. 1.3): Allan/Suzanne drove the food to the picnic/beach (Take A #1). Apparently subjects did not like the combination of the verb drive with an unrelated inanimate object, since the fill-in questionnaire elicited only animate objects or objects related to driving (distances or vehicles) with this verb. However, this implausible use occurred whichever analysis of the sentence was chosen, since it was in the first clause of the sentence, so it is unlikely to have greatly affected the Take A results.

on either analysis (2.43 and 2.83) than the Bake B sentences on the non-gapping analysis (1.91), and these differences were significant ($\underline{t}$ (12) = 3.17, $\underline{p} < 0.01$; $\underline{t}$ (12) = 3.26, $\underline{p} < 0.01$).

The Take A sentences (with gapping parallelism) received fewer gapping responses than the Bake A sentences, 40.2%, with 37.8% of those responses noting that the non-gapping analysis was also possible; the other 59.8% of the responses were non-gapping, and only 13% of those noted any ambiguity (this difference in ambiguity was significant, $\underline{t}$ (11) = 2.8, $\underline{p} = 0.02$). The Take B sentences received almost exclusively non-gapping responses (96.1%), like the Bake B sentences, and were rated as not very ambiguous on this analysis (8.7%; this ambiguity rating is also significantly lower than for the Take A gapping analysis, $\underline{t}$ (11) = 3.3, $\underline{p} < .01$). The Take A sentences were significantly more difficult on the gapping analysis (3.07) than the non-gapping analysis (2.45; $\underline{t}$ (11) = 2.95, $\underline{p} = 0.013$). The Take A sentences were also more difficult on either analysis than the Take B sentences on the non-gapping analysis (3.07 and 2.45 vs. 2.11; $\underline{t}$ (11) = 4.1, $\underline{p} = 0.002$; $\underline{t}$ (11) = 2.3, $\underline{p} < .05$). Thus the Take A sentences were rated as ambiguous in two ways. First, the responses were split more evenly than in any other condition, so subjects differed in which analysis was preferred overall. Second, when they chose the gapping analysis, they found the sentences more difficult and many of them noted that another analysis was possible.

The Introduce sentences were given gapping structures only 20.9% of the time. For these sentences, the differences in ambiguity ratings and difficulty ratings were non-significant. Comparisons between the percent gapping responses for the different conditions were all significant by subjects and items. So the Bake A sentences were rated as gapping significantly more than the Bake B sentences ($\underline{F}_1 = 438$, $\underline{p} < 0.001$; $\underline{F}_2 = 318$, $\underline{p} < 0.001$), the Take A sentences were rated as gapping significantly more than the Take B sentences ($\underline{F}_1 = 85$, $p < 0.001$; $\underline{F}_2 = 43$, $\underline{p} < 0.001$), the Bake A sentences got more gapping responses than the Take A sentences ($\underline{F}_1 = 83$, $\underline{p} < 0.001$; $\underline{F}_2 = 38$, $p < 0.001$), and the Take A sentences got more gapping responses than the Introduce sentences ($\underline{F}_1 = 24$, $\underline{p} < 0.001$; $\underline{F}_2 = 7$, $\underline{p} = 0.014$).

Discussion

Comparing the Bake A, Take A, and Introduce percentages, one can see that the sentences with the strongest gapping-biased parallelism (Take A and Bake A) received more gapping responses than the sentences with weaker parallelism (Introduce), and that the extra pragmatic bias in the Bake A sentences raised the rate of gapping responses even higher. The comparison between the Bake A and Bake B sentences shows that even when parallelism and pragmatic factors favor the gapping analysis, it is not unanimously preferred and easy, as the non-gapping analysis is in the Bake B sentences. The comparison between the Take A and Take B sentences shows that strong parallelism between arguments can significantly raise the rate of gapping responses, for the same sentence frame. Also, the Take B results show that the non-gapping analysis is overwhelmingly favored when parallelism is not clearly a factor. Finally, the difficulty and ambiguity ratings show that the gapping analysis is rated as more difficult and more ambiguous than the non-gapping analysis unless the non-gapping analysis is quite implausible (as in the Bake A sentences).

These results suggest that parallelism and plausibility do have a role to play in the interpretation of these sentences. They suggest also that structural factors are more important, however. If pure parallelism were used to structure these sentences, then the gapping analysis

should be preferred and easy in the Bake A, Take A, and Introduce sentences. The arguments in the second conjunct should be lined up in the positions corresponding to whichever argument in the first conjunct is more parallel, and this structure should be built. Since in fact the gapping analysis was only predominant (over 50%) when an extra pragmatic factor biased toward it as in the Bake A sentences, and the gapping analysis was rated as more difficult overall, the Strong Parallelism Hypothesis is disconfirmed.

The Minimal Structure Hypothesis, however, can more easily explain this pattern of results. The strong bias toward the non-gapping analysis reflects that this is the smaller, simpler structure, while the importance of parallelism and pragmatics is consistent with an evaluation of structures based on further information in the sentence. The greater difficulty and ambiguity of the gapping analysis suggests also that there is a processing cost for settling on a less economic structure. One way to implement this would be to have the parser build structures serially. In that case, the simpler structure would always be built first, and the gapping structure would involve reanalysis based on the parallelism and pragmatic information. Alternatively, both structures could be built, but additional activation of the gapping analysis through further information would be necessary to outweigh the structurally simpler non-gapping analysis. Whichever mechanism is used, though, the structural bias is clear.

3. EXPERIMENT II: PROSODY

Background and Design

The previous study showed that parallelism and word-based factors could affect the parsing of ambiguous gapping sentences, and that a general structural bias favored the lower conjunction analysis of these sentences in the absence of clear evidence to the contrary. However, auditory processing is often held to be more central to language, so it is an important question whether these results carry over to the auditory realm, since a written study may not get at the central workings of the processor. The second experiment was designed to test whether the same kind of results would be found in an auditory study as in the written study, and to evaluate in addition the relative contributions of structure and prosody to the resolution of the ambiguity of these sentences. It was also hypothesized that parallelism in the prosodic domain could play a role in the processing of these ellipsis structures.

I was concerned with two questions relevant to the prosodic representations for the sentences. On the one hand, I wanted to find out whether the results seen in the written study would hold for auditory processing, or whether they were just an artifact of the study conditions. To find the same pattern of ambiguities, I wanted to exploit a prosody that would be compatible with both interpretations of a gapping sentence, allowing the structural factors that had been important in the written study to determine the output: a Baseline prosody (Kjelgaard, 1995; Speer et al., 1996). The existence of such an ambiguous prosody would also show that gapping sentences do not require a special prosody for their interpretation. But this prosody would, by design, show no effect of prosodic structure on the analysis of the sentence, and thus would not help determine what role prosody could play in parsing. Thus I also wanted to find biasing prosodies, one that would favor the gapping analysis and one

that would favor the non-gapping analysis: Cooperating Gapping and Nongapping prosodies. With these I could examine the relative roles of prosody, prosodic parallelism, and structural factors in parsing gapping sentences. Although many possible prosodies may exist with these properties, particular instantiations had to be chosen in order to carry out this study; I will not claim to have found the only ambiguous and biasing prosodies possible for these gapping sentences, just one plausible set of them.

Work on processing and prosody goes back several decades (see Cutler, Dahan, & Donselaar, 1997, for a review). A portion of this work has focused on the relation between prosody and syntax, particularly syntactic disambiguation (e.g., Lehiste, 1973; Price et al., 1991; Speer, Kjelgaard, & Dobroth, 1996). Since prosodic choices often do not unambiguously signal syntactic structures (Pierrehumbert, 1980), these studies have tended to use clear prosodic boundaries, which may coincide with major syntactic boundaries, for disambiguation. Cooper and Paccia-Cooper (1980) found that boundary effects are also seen at ellipsis sites, signaling that prosodic boundaries are often found where syntactic deletion has taken place. These boundaries are signaled by duration and fundamental frequency (F0) differences.

In the case of the gapping sentences under discussion, however, it appeared that boundary effects would not be enough to disambiguate the structures. In particular, Cooper and Paccia-Cooper (1980) suggest that a prosodic boundary should be found between the ambiguous DP and the PP of the second conjunct in a gapping construction, due to the deletion (...and John # to Sue). However, Selkirk (1997a, b) found that one natural phrasing of a sentence with a DP and PP following the verb also has a prosodic boundary between the DP and PP. Thus a prosodic boundary can be present in the second conjunct on either analysis of a gapping construction. The boundary found in a non-gapping second conjunct is likely to be a Major Phrase boundary (Selkirk, p.c.), as opposed to the Intonational Phrase boundary in a gapping conjunct, but this difference in size is the only boundary difference. Further, in both the gapping and non-gapping analyses, a boundary is likely before and, signaling either the end of an IP or a VP. Therefore, the location of prosodic boundaries before and and to Sue can not disambiguate these gapping sentences.

However, there are other aspects of prosody that could be used in the processing of gapping sentences. First of all, the location of pitch accents could be important, as seen in other processing work (e.g., Birch & Clifton, 1995; Schafer, Carter, Clifton, & Frazier, 1996; Schafer, Clifton, Frazier, & Carlson, 1998). Pitch accents often signal the presence of new or contrastive information (Pierrehumbert, 1980; Selkirk, 1984, 1995, 1997a, b). In these sentences, the material left in the second conjunct of a gapping sentence is in a contrastive focus relation with material in the first conjunct (Johnson, 1997; Kuno, 1976; Sag, 1980), as in (8):

(8) Dan amazed the ju ges with his talent and James with his musicality.

If (8) is interpreted as a gapping sentence, then James contrasts with Dan, and with his musicality contrasts with with his talent. The conjuncts are two different instantiations of X amazed the judges with Y, and each conjunct puts in different values for X and Y. Similarly,

if (8) is a non-gapping conjunction, James contrasts with the judges, and with his musicality contrasts with with his talent. Either way, the second conjunct constituents will contrast with information in the first conjunct, and thus receive pitch accents. Biased prosodies could vary the placement of pitch accents in the first conjunct, then, to mark which arguments in the first conjunct contrast with arguments in the second conjunct. This accent placement will clearly increase the parallelism of corresponding arguments in the conjuncts.

Another prosodic variable is the choice of pitch accent types. The prosodic theory of Pierrehumbert (1980) and Beckman and Pierrehumbert (1986) allows for several different types of pitch accents, which may correlate with particular discourse situations (Pierrehumbert and Hirschberg, 1990). In the present study, the parallelism of corresponding arguments might be increased by choosing similar pitch accents.

Finally, the pitch range used can affect processing. Marcus and Hindle (1990) present a theory of parsing in which pitch range and prominence information are used to structure material within prosodic boundaries. Several processing studies have found that the discourse structure of a long utterance (such as a set of instructions or a paragraph) can be highlighted by the use of pitch range, with higher pitch peaks being found for high-level topic changes and lower pitches at topic ends (e.g., Lehiste, 1975, 1979; Swerts & Geluykens, 1994). Studies have also examined the relation between focus conditions and pitch peak height within a sentence (Bartels & Kingston, 1994; Rump & Collier, 1996), and found that the relative heights of pitch peaks can favor different discourse interpretations of sentences, with the location and choice of pitch accents held constant. In the present experiment, parallelism of pitch range will be used to highlight arguments in a contrastive relation to each other. Thus three prosodic factors have been identified here that will be used to produce biased prosodies by varying the parallelism of arguments in the two conjuncts.

Prosodic Hypotheses. In designing this experiment, I was testing the following general hypothesis:

(9) General Prosodic Hypothesis
a. Baseline: there exists a natural prosody which is compatible with both interpretations of gapping sentences, and which allows the biases of the sentence construction to be seen
b. Cooperating: there exist prosodies which favor the gapping and the non-gapping interpretations of these sentences, so prosody can be shown to affect the processing of these sentences

That is, I wanted to find a prosody that would leave the sentences ambiguous, as well as prosodies which would bias perceivers toward the gapping and non-gapping interpretations. The existence of prosodic representations with these properties would show that a gapping structure could be reached without a "special" prosody (one unique to gapping). Before this study, it was not known whether gapping structures were available with an ambiguous prosody. This result would also show that prosodic factors could nevertheless affect the processing of ambiguous gapping sentences. Specifically, it would show that pitch accent type, range, and placement could be used to bias interpretation, despite ambiguous prosodic

boundaries. To my knowledge, neither of these hypotheses had been tested before, so the influence of prosody on the processing of gapping structures was quite unknown. Besides testing for the existence of prosodic effects on processing, this experiment was designed to evaluate the relative roles of prosodic parallelism and structural economy on the auditory processing of gapping sentences.

If the Strong Parallelism Hypothesis holds for auditory processing despite its problems in the written domain, and prosodic parallelism is the central factor in the processing of a gapping sentence, then a gapping analysis should be reached whenever the ambiguous DP has the same pitch accent and range as the subject of the first conjunct and not the object. If the Minimal Structure Hypothesis holds, and structural economy is still more important, then prosodic parallels should only be able to slightly raise the base rate of gapping responses for a sentence in the Cooperating Gapping condition, and slightly lower it in the Cooperating Nongapping condition.

To sum up, this experiment was intended to test whether there are Baseline and Cooperating prosodies for gapping sentences. The Baseline prosody should allow whatever structural bias the sentence has to determine the interpretation, and thus should show the same pattern of results as the visual experiment. The Cooperating prosodies should allow prosody to bias the interpretation. The experiment also tested how much Cooperating prosody can affect the interpretation, in order to decide whether the Minimal Structure hypothesis is correct or whether prosodic parallels can have a very central role in processing.

Method

Subjects. Fifty-one undergraduates who were taking Psychology courses at the University of Massachusetts participated in this study in exchange for course credit. All were native English speakers.

Stimuli. The experimental sentences used in this study were taken directly from the questionnaire in experiment I, so that the results could be compared. Sentences of the Take A (variable object) variety were used for the Baseline condition. These were the most ambiguous sentences in the written study, with a 40% gapping response rate, and it was hoped that a similar result could be achieved with a neutral prosody. Sentences of the Introduce (animate object) variety were used for the Cooperating conditions.[6] These sentences were found to be fairly biased against a gap reading in the questionnaire study, with a 21% gapping response rate, although both interpretations had sensible meanings (unlike the Bake sentences, which had strong pragmatic biases). Thus these sentences left a lot of room to show the effects of Cooperating Gapping prosody, if it could raise the rate of gapping responses. Each Introduce sentence was produced with both the Cooperating Gapping and

[6]This experimental design was chosen so that several sets of auditory results could be compared to the results of the questionnaire study. That is why different sets of sentences were produced using the Baseline vs. Cooperating prosodies. Another possible design would have tested ambiguous and biased prosodies on one type of sentence. This would have enabled the three different prosodic structures to be compared directly, but would have allowed only one point of comparison to the questionnaire study.

Cooperating Nongapping prosody (but each subject heard only one version of any particular sentence). The sentence types are exemplified in Table 4 and described below:

Table 4: Sentences for Experiment II

Condition	Example sentences
Baseline prosody: Take A sentences	Jane recommended a movie to her co-worker and Doris to the boss
Cooperating Gapping prosody: Introduce sentences	[Bob insulted the guests during dinner] and [Sam during the dance]
Cooperating Non-gapping prosody: Introduce sentences	Bob insulted [the guests during dinner] and [Sam during the dance]

The prosodies will be described using the ToBI transcription system (Beckman & Ayers, 1994), which is based on the intonational phonology system of Pierrehumbert (1980). In the Cooperating prosodies, I chose to use parallel placement of pitch accents, parallel pitch accent types, and parallel pitch peak heights all at once, in order to maximize the helpful effect of the prosody on the structuring of the sentences. The Cooperating Gapping prosody has the form shown in (10):

(10) Cooperating Gapping prosody
BOB insulted the guests during DINNER and SAM during the DANCE
L* H- H* L- H% L* H- H% H* L- L%

Both elements in the second conjunct are accented, since they are contrastive with elements in the first conjunct. In the first conjunct, only the subject and PP are accented, but not the object. Thus the ambiguous DP (Sam) is more parallel to the subject of the first conjunct than the object, favoring a gapping analysis. On the subjects of both conjuncts (Bob and Sam) there are L* accents followed by H- phrase tones; on both PPs there are L+!H* accents. And not only are parallel pitch accents used on corresponding elements in the two conjuncts, but the actual F0 values reached during the accents are very similar. That is, the H* accents on the PPs reach similar heights, which are in a different pitch range than the H tones at the edges of the subject DPs. Intonational Phrase boundaries are found following dinner and Sam; the large boundary after Sam slightly favors a gapping analysis. The bias towards a gapping analysis was confirmed by several informants, as well as the results of this experiment.

The Cooperating Non-gapping prosody is quite similar to the Cooperating Gapping prosody above, differing only in the placement of accents in the first conjunct and the size of the boundary in the second conjunct, as in (11):

(11) Cooperating Non-gapping prosody
Jane asked my DAD about his CAREER and SHARON about POLITICS
H* L* H- H* L- H% L* H- H* L- L%

Here the parallel L* accents followed by H- phrase tones are placed on the object of the first conjunct and the ambiguous DP, while the accents on the PPs are identical to those seen in Figure (10). Again, parallelism between corresponding elements is highlighted by their realization in similar pitch ranges with the same type of pitch accents. A non-prominent H* pitch accent is seen on the subject of the first conjunct, possibly due to a preference for a pitch accent near the beginning of a prosodic phrase (Selkirk, p.c.). An Intonational Phrase boundary is present at the end of the first conjunct, but there is only a Major Phrase boundary between the ambiguous DP and the PP in the second conjunct. The larger prosodic boundary for the gapping prosody in (10) is probably motivated by a combination of the preference for a boundary after a focused element and the preference for a boundary at a deletion site.

The Baseline condition prosody is quite different from the Cooperating prosodies above. First of all, pitch accents are present on all of the arguments of the sentence, rather than being restricted to the pairs of elements in a contrastive focus relation. This means that the pitch accent location does not favor one analysis over the other. Secondly, the pitch accents in the sentence are all the same (H*), so the choice of pitch accent types also shows no exclusive parallels between arguments. Finally, the pitch range parallels seen in the other prosodies are not produced here. The accents in the first conjunct follow a neutral downstepping pattern, and the ambiguous DP is not clearly more parallel in pitch to either argument in the first conjunct. This is consistent with a failure to anticipate, within the first conjunct, any contrastive focus relationships between arguments in the two conjuncts. These properties can be seen in (12):

(12) Baseline prosody

Jane recommended a movie	to her co-worker	and Doris	to the boss
H* L-	!H* L-	!H* L- H%	H* !H- L%	H* L- L%

There is an Intonational Phrase boundary in the second conjunct, which is consistent with either a gapping or non-gapping interpretation, but slightly favors a gapped reading. Due to the lack of parallelism in pitch accent location and choice, this prosody has the potential to leave the sentence quite ambiguous. In addition, the H* accents on all arguments make this prosody a logical choice for an out-of-the-blue utterance, with all of the arguments presenting new information (Pierrehumbert and Hirschberg, 1990; Selkirk p.c.); this discourse situation is quite unmarked, so this prosody is more natural than one that requires more specific or contrastive focus conditions.

The sentences in this experiment were recorded on cassette tapes by a native speaker of English with training in prosody and a relatively neutral northern California accent. The stimuli were then digitized (in ESPS xwaves and Wave formats) for analysis and playback by a computer. They were checked for consistency in several ways. Several colleagues with experience in prosody listened to the sentences to check that the prosody appropriate for each condition had been produced. Pitch tracks of each item were given a full ToBI transcription, in order to check that the same prosodic properties were produced for all items in each condition. The properties that were checked included the choice and location of pitch accents and prosodic boundaries. Measurements of the pitch peaks of each experimental sentence were taken, which showed great consistency between sentences of each type (SDs

ranged from 6-15 Hz). The durations of pauses were measured to check that similar pauses had been produced at the correct locations in each sentence. Baseline prosodies were produced with a pause before and (average duration = 332.5 ms) and a pause after the ambiguous DP (412.3 ms). Cooperating Gapping sentences had pauses in the same locations (444.7 ms and 395 ms), as did Cooperating Non-gapping prosodies (241 ms and 82 ms). These durations support the tonal analysis of the sentences above: all conditions had Intonational Phrase boundaries before and, the Baseline and Cooperating Gapping prosodies had Intonational Phrase boundaries after the ambiguous DP, and the Cooperating Non-gapping prosody had a Major Phrase boundary after the ambiguous DP.

Procedure. Each subject heard all 12 Take A sentences with the Baseline prosody, 5 Introduce sentences with the Cooperating Gapping prosody, and 5 Introduce sentences with the Cooperating Non-gapping prosody. Two types of filler sentences were also included in the experiment: adverb clause fillers (e.g., Susie learned that Bill telephoned after John visited) with varying boundaries and H* pitch accents on arguments, and relative clause fillers (e.g., I asked the pretty little girl who's cold) with L* accents and one H* prominence that varied in location. Each subject heard a total of 58 sentences, in an individually randomized order. (See the Appendix for a listing of the experimental sentences in this study.)

The sentences were played through speakers into a sound-proof booth with a computer screen and two levers. Subjects pressed a lever to hear a sentence, and then pressed again when they had heard and understood the sentence. This caused a question to appear on the screen, with two answers below it, one on the left and one on the right. Subjects pressed the left or right lever to choose the answer that best fit what they thought the sentence meant. For the experimental sentences, the question asked subjects to choose the best paraphrase of the sentence they had heard. The position of the answer was varied so that half of the time the gapping response was on the left, and half the time it was on the right. The paraphrases used were the same ones that had been used in the questionnaire study. A computer recorded response times and response choices.

Results and Discussion

The major results from this study are the percentages of gapping responses in the various conditions, as shown in Table 5, and how they compare to results from the questionnaire study.

Table 5: Results for Experiment II

Conditions	Response % by Subjects	Questionnaire %
Baseline: Take A	38.3% gapping	40.2% gapping
Cooperating Gap: Introduce	44.1% gapping	20.9% gapping
Cooperating Non: Introduce	27.5% gapping	

The first line of Table 5 shows that the Baseline prosody performed as intended: the results of the auditory study replicated the results of the questionnaire study almost exactly (by items, 38.4% compared to 39.5% gapping responses, $r = .727$; difference non-significant, $t(12) =$

.26, $p = .8$). So the Baseline prosody did not bias the interpretation, and the structural factors that had produced the written results were able to have the same effect in the auditory study. The Take A sentences in this condition could take human or non-human objects, so the ambiguous DP could be an object or subject. But only the ambiguous DP and the subject of the first conjunct were made structurally parallel. Thus these sentences were rated in both studies as possible but ambiguous gapping sentences. This confirms part (a) of the General Prosodic Hypothesis: there is a natural Baseline prosody that is neutral with respect to the gapping and non-gapping interpretations. This also shows that the results of the questionnaire study are not artifacts of written language, since the Baseline prosody produced clearly comparable results. Finally, this confirms that the gapping analysis does not demand a specific prosody to be constructed.

The Cooperating Gapping prosody produced more gapping responses than the Cooperating Nongapping prosody, 44.1% to 27.5%. This difference was highly significant by subjects (t (51) = 4.285, $p < 0.001$) and by items (t (10) = 3.041, $p = 0.014$). So the prosodic differences between the conditions were able to affect the processing of these sentences. Specifically, subjects were able to use the prosodic parallelism between the ambiguous DP and a corresponding first clause argument to help determine the final sentence structure. Also, part (b) of the General Prosodic Hypothesis is confirmed, since there are biased prosodies that produce higher and lower gapping response rates. Further, the structure of the biased prosodies suggests that not only phrase breaks, but also parallelism of pitch accents and pitch range can be used in processing to favor different syntactic structures.

However, the difference between the gapping response percentages for the Cooperating prosody conditions, though significant, was not very large: 16.6%, and neither prosodic condition received a majority of gapping responses. Thus the hypothesis that there are prosodies that favor the gapping and non-gapping interpretations is confirmed, but the Strong Parallelism Hypothesis is not supported in the auditory realm either. This hypothesis predicted that the parallelism found in Cooperating prosodies should dictate the favored structural analysis of these sentences. Here, the prosodic effect was not seen to outweigh the structural biases of the sentences and there is no evidence that prosody is the central mechanism for interpreting these sentences.

In the written study all of the experimental sentences received well over 50% non-gapping responses, except when the non-gapping interpretation of the sentences was anomalous (as in the Bake A sentences, which got only 18.9% non-gapping responses). Also, subjects who took the gapping analysis of sentences generally rated them as more ambiguous or difficult than those who chose the non-gapping analysis. These results supported the idea that the economic non-gapping structure was preferred, even if the parallelism of arguments suggested otherwise. In the auditory study, the non-gapping structure was still overwhelmingly favored, in all conditions. The effect of prosody seen here is comparable in size to the effects of verb type or argument parallelism in the questionnaire study, so the prosody seems to be a factor of only as much importance as these variables in determining the ultimate analysis of these sentences. The strongest Minimal Structure Hypothesis predicted that the most economic syntactic structure would be the preferred analysis, with other factors

like prosodic parallelism influencing the choice between structures. Thus this remains the best model for processing these sentences in either modality.

One thing is a bit puzzling about this data compared to the results of the questionnaire study: the gapping response rates for both the Cooperating Gapping and the Cooperating Nongapping prosodies were higher than the gapping response percentage found in the written study (44.1% and 27.5% vs. 20.9%, respectively). We might have expected a lower gapping response rate for the Cooperating Nongapping condition than in the questionnaire. Perhaps the Introduce sentences were particularly hard to read as gapping structures, and improved a great deal simply by being spoken. In addition, the pitch accent choices in the Cooperating Non-gapping prosody may have been consistent with a gapping analysis. Specifically, the small but perceptible pitch accent on the subject of the first conjunct in this prosody may have been enough to make this argument a possible contrastive element to the ambiguous DP, though not an overtly parallel one. Perhaps this is the reason that the gapping analysis appeared to be more plausible in this auditory study than in the questionnaire study.

In both the auditory and written studies, subjects' responses to these sentences differed, with some choosing the gapping analysis for almost all sentences and others rarely choosing the gapping analysis. These subject differences did not correlate with handedness, SAT scores, or other information which was collected about the subjects. This is reminiscent of the many debates in the linguistics literature about the acceptability of various gapping sentences (as reviewed in Sag, 1980), and the results of my own informal surveys of linguists and friends. These gapping sentences seem to be marginal for some people, while other people freely accept them in many forms. It seems unlikely, then, that the simple task of choosing a paraphrase of these sentences forced these subject differences.[7]

Overall, the results of this auditory study support the results of the questionnaire study. A Baseline prosody was found which is a natural way to pronounce a gapping sentence, but allows the ambiguity of the sentence to emerge just as in reading. This suggests that the questionnaire study shows something real about the processing of these sentences, and that the structural factors identified in that study are also relevant to auditory processing. It also shows that gapping structures can be built in the absence of biasing prosodic information. Cooperating prosodies were found that favor gapping and non-gapping interpretations of these sentences, though the bias they added was under 20%. So there is a role for prosodic parallelism in the processing of these sentences, but not a central role, as the biased prosodies did not disambiguate the sentences. A Minimal Structure account is more consistent with the overall pattern of results in these experiments.

4. Conclusion

Ambiguous gapping sentences seem to be assigned an interpretation based mostly on structural economy, since a bias toward non-gapping structures was found in all experimental

[7]There were some differences between items in both studies as well. These response differences did not correlate with specific differences in form between sentences (for example, definite subjects vs. proper name subjects), and are assumed to be due to a complex of lexical factors.

conditions (except Bake A). This evidence supports the Minimal Structure hypothesis about the processing of gapping sentences. Specifically, this suggests that perceivers favor structural economy in processing, though they can consider many types of information in determining an interpretation. This work is consistent with a view of processing as a modular system in which the simplest structures are built first and then reanalyzed based on semantic and parallelism information (as in the Garden Path model). A model with reanalysis would also explain why the gapping analysis is rated as more ambiguous or difficult than the non-gapping analysis; it would only be built as a second structure, subsequent to processing of other information. The results are also derivable through the interaction of weighted constraints, as long as structural preferences (based on economy or frequency) are most heavily weighted (e.g. Tanenhaus, Spivey-Knowlton, & Hanna, 1996). Finally, this hypothesis proposes that the processing of gapping sentences can be captured without any special, construction-specific mechanism, and instead follows general principles of language processing.

The results show that factors such as verb type and parallelism between conjuncts (including prosodic parallelism) are important factors in the processing of gapping sentences, since there were significant response differences between experimental sentences with different parallels between conjuncts. But the Strong Parallelism Hypothesis, which gives parallelism a central role in processing, gave the wrong predictions about gapping sentences. The more economic structure was preferred in the Take A and Introduce sentences, despite parallelism that favored the gapping structure; only when plausibility also favored the gapping structure, as in Bake A sentences, was the economic structure not preferred. Thus it is plausible that factors like parallelism mainly influence the activation of a less economic structure or lead to the reanalysis of sentences which have been given the favored non-gapping syntactic structure.

As the first known auditory study of ambiguous gapping sentences, the second experiment significantly furthers our knowledge of the processing of these structures. Closely comparable results were obtained in the visual processing study and the ambiguous (Baseline) prosodic condition. Therefore, the results cannot be due to gapped sentences only occurring in speech or only in written language. This also shows that a neutral prosody exists which allows either analysis of a gapping sentence to be chosen, depending on what other biases are present in the sentence. Gapping sentences thus are not so exotic that they can only be interpreted as gapping structures with a specific prosody. In addition, this Baseline prosody shows that the presence of a prosodic boundary at the ellipsis site was not enough to disambiguate these sentences.

Biased prosodies were also found. These Cooperating prosodies involved only a small difference in boundary size, and primarily differed in the location of pitch accents within the unambiguous first clause. The different pitch accent locations led to different parallelism conditions between the ambiguous DP and first clause arguments. The effects seen in these conditions support the idea that parallelism of many types is helpful in the processing of conjoined elements. The results also confirm that prosodic boundaries are not the only prosodic variables that can influence syntactic processing. Finally, all of the prosodic results support the prosodic assumptions used to generate the prosodies; parallelism of pitch accent

type, range, and location was found to bias sentence interpretation in a case where prosodic boundaries could not disambiguate the sentences.

Prosody has been discussed above as if it could play no role in the initial structuring of an input. For auditory processing, this can not be wholly true. A prosodically structured string appears to be the input that the parser receives. The full phonological representation of such input may not be computed immediately, however. The interpretation of prosodic elements can depend on the syntactic and semantic representations of a sentence, so full realization of the consequences of a prosodic choice might have to wait until these other representations are computed. This research shows that an auditory version of the Strong Parallelism hypothesis, in which prosodically parallel arguments are lined up on that basis initially and then syntactically structured, can not be right. Prosodic choices were not seen to override the structural biases of sentences, so the asymmetry between the gapping and non-gapping analyses was still present.

There are many questions for further research raised by these experiments. For example, the prosodies used here were constructed to test many aspects of prosody at once. A further study might separate these, so that one could clearly test the relative contributions of prosodic boundary sizes, pitch accents, and pitch range on processing. There may be other prosodies, with different choices of pitch accents, that would show even larger prosodic effects. Also, deletion structures of many types occur in conjoined sentences where parallelism is likely to play a role. Further research on ambiguous and unambiguous deletion structures should provide more evidence for the contribution of parallelism of many types to processing, and help determine the domain of sentence types for which parallelism is important. Finally, on-line studies of parallelism and deletion structures will help sort out the way that structural economy and other factors interact to determine an interpretation.

References

Altmann, G., Henstra, G., & Garnham, A. 1993. Processing Coordinated Structures. Poster presented at the 6th Annual CUNY Conference on Human Sentence Processing.

Bartels, C., & Kingston, J. 1994. Salient pitch cues in the perception of contrastive focus. Ms., University of Massachusetts, Amherst.

Beckman, M., & Ayers, G. 1994. *Guidelines for ToBI transcription*, vers. 2.0. Ms. and accompanying speech materials, Ohio State University.

Beckman, M., & Pierrehumbert, J. 1986. Intonational structure in English and Japanese. *Phonology Yearbook*, **3**, 255-310.

Birch, S., & Clifton, C. E. 1995. Focus, accent, and argument structure: Effects on language comprehension. *Language and Speech*, **38**, 365-391.

Black, M., Coltheart, M., & Byng, S. 1985. Forms of coding in sentence comprehension during reading. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 655-672). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cooper, W., & Paccia-Cooper, J. 1980. *Syntax and speech*. Cambridge: Harvard University Press.

Cutler, A., Dahan, D., & Van Donselaar, W. 1997. Prosody in the comprehension of spoken language: A literature review. *Language and Speech*, **40**, 141-201.

Dalrymple, M., Shieber, S., & Pereira, F. 1991. Ellipsis and higher-order unification. *Linguistics and Philosophy*, **14**, 399-452.

Frazier, L. 1978. *On comprehending sentences: Syntactic parsing strategies*. Bloomington: Indiana University Linguistics Club.

Frazier, L. 1987. Sentence processing: A tutorial review. In M. Coltheart (Ed.), *Attention and performance XII* (pp. 559-585). Hillsdale, NJ: Lawrence Erlbaum Associates.

Frazier, L., & Rayner, K. 1982. Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, **14**, 178-210.

Frazier, L., Clifton, C. E., & Munn, A. 1997. Processing coordinate structures. Ms., University of Massachusetts, Amherst.

Frazier, L., Taft, L., Roeper, T., Clifton, C. E., & Ehrlich, K. 1984. Parallel structure: A source of facilitation in sentence comprehension. *Memory and Cognition*, **12**, 421-430.

Gibson, E., Schutze, C., & Salomon, A. (1996) The relationship between the frequency and the processing complexity of linguistic structure. Journal of Psycholinguistic Research, **25**, 59-92.

Grosu, A. 1985. Subcategorization and parallelism. *Theoretical Linguistics*, **12**, 231-240.

Hankamer, J. 1971. *Constraints on deletion in syntax*. Unpublished doctoral dissertation, Yale University.

Johnson, K. 1997. Bridging the gap. *In search of the english middle field*, Chapter 2. Ms., University of Massachusetts, Amherst.

Kjelgaard, M. M. 1995. *The role of prosodic structure in the resolution of phrase-level and lexical syntactic ambiguity*. Unpublished doctoral dissertation, Northeastern University.

Kuno, S. 1976. Gapping: A functional analysis. *Linguistic Inquiry*, 7, 300-318.

Larson, R. 1988. On the double object construction. *Linguistic Inquiry*, **19**, 335-391.

Lehiste, I. 1973. Phonetic disambiguation of syntactic ambiguity. *Glossa*, **7**, 107-122.

Lehiste, I. 1975. The phonetic structure of paragraphs. In A. Cohen & S. G. Nooteboom (Eds.), *Structure and process in speech perception: Proceedings of symposium on dynamic aspects of speech perception* (pp. 195-206). Berlin, Heidelberg, New York: Springer-Verlag.

Lehiste, I. 1979. Perception of sentence and paragraph boundaries. In B. Lindblom & S. Oehman (Eds.), *Frontiers of speech communication research* (pp. 191-201). New York: Academic Press.

Marcus, M., & Hindle, D. 1990. Description Theory and intonation boundaries. In G. Altmann (Ed.), *Cognitive models of speech processing: Computational and psycholinguistic perspectives* (pp. 483-512). Cambridge, MA: MIT Press.

Pierrehumbert, J. 1980. *The phonetics and phonology of English intonation*. Ph.D. Dissertation, MIT.

Pierrehumbert, J., & Hirschberg, J. 1990. The meaning of intonational contours in the interpretation of discourse. In P. R. Cohen, J. Morgan, & M. E. Pollock (Eds.), *Intentions in communication* (pp. 271-311). Cambridge, MA: MIT Press.

Price, P., Ostendorf, M., Shattuck-Hufnagel, S., & Fong, C. 1991. The use of prosody in syntactic disambiguation. *Journal of the Acoustical Society of America,* **90**, 2956-2970.

Rump, H. H., & Collier, R. 1996. Focus conditions and the prominence of pitch-accented syllables. *Language and Speech,* **39**, 1-17.

Sag, I. A. 1980. *Deletion and logical form*. New York: Garland Publishing.

Schafer, A., Carter, J., Clifton, C. E., & Frazier, L. 1996. Focus in relative clause construal. *Language and Cognitive Processes,* **11**, 135-163.

Schafer, A., Clifton, C. E., Frazier, L., & Carlson, K. 1998. Focus and the interpretation of pitch accent: Disambiguating embedded questions. Unpublished manuscript, University of Massachusetts, Amherst.

Selkirk, E. O. 1984. *Phonology and syntax: The relation between sound and structure*. Cambridge, MA: MIT Press.

Selkirk, E. O. 1995. Sentence prosody: Intonation, stress, and phrasing. In J. Goldsmith (Ed.), *Handbook of phonological theory* (pp. 550-569). Oxford and Cambridge, MA: Basil Blackwell Publishers.

Selkirk, E. O. 1997a. The interaction of constraints on prosodic phrasing. In M. Horne (Ed.), *Festschrift Gosta Bruce*. Kluwer.

Selkirk, E. O. 1997b. Constraints on prosodic phrasing and their relevance for right node raising. Handout from talk delivered at SUNY Stony Brook, February 1997

Speer, S., Kjelgaard, M., & Dobroth, K. 1996. The influence of prosodic structure on the resolution of temporary syntactic closure ambiguities. *Journal of Psycholinguistic Research,* **25**, 249-271.

Swerts, M., & Geluykens, R. 1994. Prosody as a marker of information flow in spoken discourse. *Language and Speech*, **37**, 21-43.

Tanenhaus, M. K., Spivey-Knowlton, M. J., & Hanna, J. E. 1996. Modeling thematic and discourse context effects within a multiple constraints framework: Implications for the architecture of the language comprehension system. Ms., University of Rochester.

Appendix

Gapping sentences:
Bake A and B

1. A. Alice bakes cakes for tourists and Caroline for her family
   B. Alice bakes cakes for tourists and brownies for her family
2. A. Matt herds sheep in the mountains and Jason in the valleys
   B. Matt herds sheep in the mountains and goats in the valleys
3. A. The doctor wore pearls to the conference and the nurse to the benefit
   B. The doctor wore pearls to the conference and emeralds to the benefit
4. A. Sue gave cookies to the kids and Jennie to the neighbors
   B. Sue gave cookies to the kids and pecans to the neighbors
5. A. Megan put books on the desk and Jim on the bookshelf
   B. Megan put books on the desk and CDs on the bookshelf
6. A. Robin tells jokes to adults and Saundra to children
   B. Robin tells jokes to adults and stories to children

7. A. John built tables for the new school and Sheldon for the Senior Center
   B. John built tables for the new school and shelves for the Senior Center
8. A. The lawyer bought candy for the secretaries and the chef for his wife
   B. The lawyer bought candy for the secretaries and balloons for his wife
9. A. Amanda sliced vegetables for the salad and Joan for the stew
   B. Amanda sliced vegetables for the salad and beef for the stew
10. A. Mark picked wallpaper for the bedrooms and Andrea for the dining room
    B. Mark picked wallpaper for the bedrooms and carpet for the dining room
11. A. The faculty washed dishes after the reception and the students after the party
    B. The faculty washed dishes after the reception and silverware after the party
12. A. The neighbors sold lawn furniture at a yard sale and the pastor at the church bazaar
    B. The neighbors sold lawn furniture at a yard sale and old dishes at the church bazaar
13. A. Tina mixed martinis for her parents and Alexandra for her friends
    B. Tina mixed martinis for her parents and daiquiris for her friends
14. A. Mom mended socks with a needle and Janie with a sewing machine
    B. Mom mended socks with a needle and jeans with a sewing machine

Take A and B

1. A. Allan drove the food to the picnic and Suzanne to the beach
   B. Allan drove Theresa to the picnic and Suzanne to the beach
2. A. Gregory discusses politics with his wife and Steve with his secretary
   B. Gregory discusses Melanie with his wife and Steve with his secretary
3. A. Pete took cookies to school and Mary to the park
   B. Pete took the kids to school and Mary to the park
4. A. Jane recommended a movie to her co-worker and Doris to the boss
   B. Jane recommended Justine to her co-worker and Doris to the boss
5. A. Josh visited the office during the vacation and Sarah during the week
   B. Josh visited Marjorie during the vacation and Sarah during the week
6. A. Patrick criticized the food at the dinner and Joanna at the party
   B. Patrick criticized Bridget at the dinner and Joanna at the party
7. A. The guest of honor found dust in the living room and the hostess in the dining room
   B. The guest of honor found Dave in the living room and the hostess in the dining room
8. A. The director brought chips to the party and Susan to the potluck
   B. The director brought Marie to the party and Susan to the potluck
9. A. Samantha replaced the plants in the office and Janice at the front desk
   B. Samantha replaced the intern in the office and Janice at the front desk
10. A. The mayor discussed finances with his aides and the fire chief with the councilmen
    B. The mayor discussed the judge with his aides and the fire chief with the councilmen
11. A. Tammy described the zoo to her mother and Susie to her sister
    B. Tammy described Amelia to her mother and Susie to her sister
12. A. Jason brought his cleats to practice and Bob to the game
    B. Jason brought his sister to practice and Bob to the game

Introduce

1. Theresa introduced a new policeman to the mayor and Susan to the councilmen

2. The producer invited an actress to the premiere and the director to the party
3. Jane asked my dad about his career and Sharon about politics
4. The diplomat met some senators at the reception and the ambassador at a meeting
5. Morgan annoyed my mother with his questions and David with his clumsiness
6. Joan complimented the hosts on the decorations and Tanya on the food
7. The president misled investors during the campaign and the vice-president during the cover-up
8. Dan amazed the judges with his talent and James with his musicality
9. Bob insulted the guests during dinner and Sam during the dance
10. Grandma scolded Jenny about her manners and Aunt Viv about her posture

Filler sentence examples from prosody study:
Adverb clause (# marks an Intonational Phrase break):
1. A. Susie learned that Bill telephoned # after John visited.
   B. Susie learned that Bill telephoned after John visited.

Relative Clause (bold marks the H* pitch-accented word, others are low):
1. a. I asked the pretty little girl **who's** cold
   b. I asked the pretty little girl who's **cold**
   c. I asked the pretty little girl **who** is very cold
   d. I asked the pretty little girl who is very **cold**

Department of Linguistics
South College
University of Massachusetts
Amherst, MA 01003

katyc@linguist.umass.edu